NCEP's Role in a National Unified Weather-Climate Modeling Strategy

Chris Bretherton (University of Washington)

Outline

- NRC report on 'A National Strategy for Advancing Climate Modeling' – scope, issues, status.
- NCEP CFSv2: A tough act to follow.
- Personal thoughts about NCEP's role in the future of US unified weather-climate modeling.

A National Strategy for Advancing Climate Modeling

A Study from the National Academy of Sciences

Chris Bretherton, Chair
Edward Dunlea, Study Director

- Overall goals
  - How to improve climate modeling in next 10-20 years
  - Big picture look at whole of US climate modeling
  - Holistic approach
- History
  - Initiated with conversations with Navy, DOE, and Intelligence Community
    - Users of climate models
- Funding
  - DOE, NASA, NSF, NOAA, and Intelligence Community

Committee

- Chris Bretherton (Chair)
  - University of Washington
- V. Balaji
  - Princeton University
- Thomas Delworth
  - NOAA / GFDL
- Robert E. Dickinson
  - University of Texas
- James S. Famiglietti
  - U. of California, Irvine
- James A. Edmonds
  - PNNL (Maryland)
- Inez Fung
  - Univ. of California, Berkeley
- James J. Hack
  - Oak Ridge National Lab
- James W. Hurrell
  - NCAR
- Daniel J. Jacob
  - Harvard University
- James L. Kinter III
  - COLA
- Lai-Yung Ruby Leung
  - PNNL
- Shawn Marshall
  - University of Calgary
- Wieslaw Maslowski
  - Naval Postgraduate School
- Linda Mearns
  - NCAR
- Richard B. Rood
  - University of Michigan
- Larry L. Smarr
  - Calit2

Process

- Five meetings throughout 2011.
- April 2011 Community Workshop, NCAR

  50 participants, lots of discussion.
- Also Heard from:

  Sponsoring agencies
  USGCRP, OSTP/OMB
  NCAR, GFDL, NCEP, UKMO, ECMWF
  Climate model users, PCMDI
- March 2012: Report sent out for external review. 13 reviews received late-April 2012; now in response phase.
- Summer 2012: Deliver report

Content of report is confidential until report is released

…but some issues discussed in our meetings were…

1) What do model prediction systems of the future look like?
   - Breadth of earth system modeling
   - Seamless prediction: weather / climate interface, regional/global interface
   - Maintaining an interoperable hierarchy of models
   - Role of regional, global and 'hybrid' models
   - Balance between 'application-driven' and 'science-driven' modeling

2) Evolving computational environment
   - Returning climate modeling to the forefront of supercomputing?
   - Codes must develop extreme parallelism to achieve exascale potential
   - Data explosion – a storage, dissemination, and interpretation challenge
   - Sophisticated, adaptive software engineering
   - Effective collaboration: how to best exploit available human resources

3) User requirements– hardware, software, data analysis, human capital
   - Helping diverse user communities get the most out of model output firehose.
   - Predictability, credibility, and uncertainty quantification.
   - Communicating model uncertainty and how to work with it.
   - Keeping our user communities informed and being responsive to their needs.
   - Role of national operational climate modeling

4) Structural issues
   - Workforce issues in climate model development
   - Fostering collaboration in a multiagency, multi-objective, multi-group environment
   - Value of international model intercomparisons (CMIP, WCRP)

CFSv2: A remarkably skillful climate model …and a tough act to follow

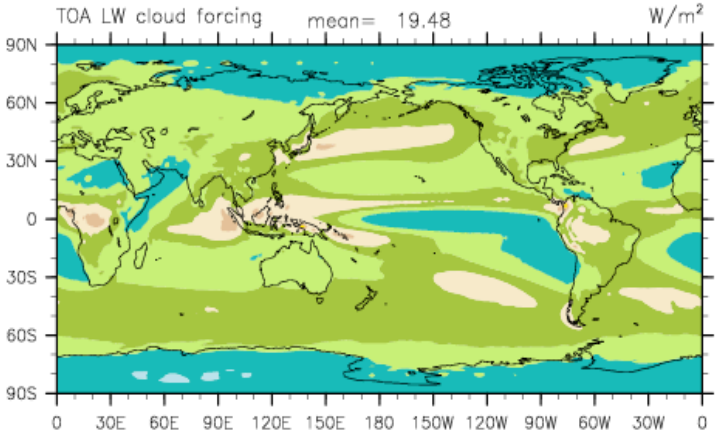
cor coef: Space-Time	cam3_5_fv1.9x2.5	NCEP_GFS	NCEP_CFSv2
	ANN	ANN	ANN
Sea Level Pressure (ERA40)	0.949	0.956	0.973
SW Cloud Forcing (CERES2)	0.707	0.408	0.625
LW Cloud Forcing (CERES2)	0.820	0.781	0.812
Land Rainfall (30N-30S, GPCP)	0.785	0.751	0.800
Ocean Rainfall (30N-30S, GPCP)	0.802	0.733	0.817
Land 2-m Temperature (Willmott)	0.876	0.911	0.938
Pacific Surface Stress (5N-5S,ERS)	0.872	0.834	0.885
Zonal Wind (300mb, ERA40)	0.967	0.957	0.975
Relative Humidity (ERA40)	0.900	0.906	0.909
Temperature (ERA40)	0.912	0.984	0.986

Free-run climatology of CFSv2 beats coupled 2011 GFS in all the above climate metrics, and NCAR model on all but clouds!

In future, try to:

- Bring CFS model improvements back into operational GFS?
- Assess climate impacts of GFS model changes?

NCEP_CFSv2 (yrs 1-30)



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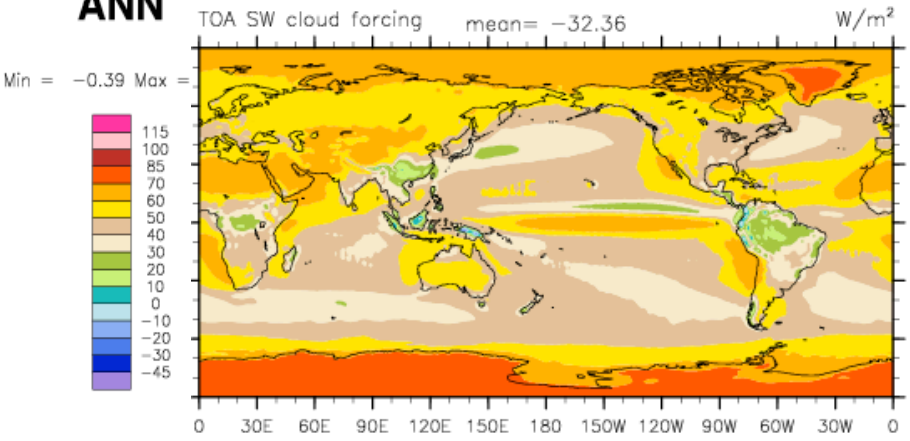

NCEP_CFSv2 (yrs 1-30)

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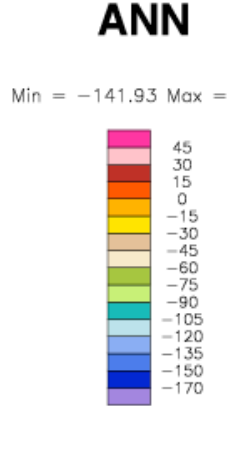
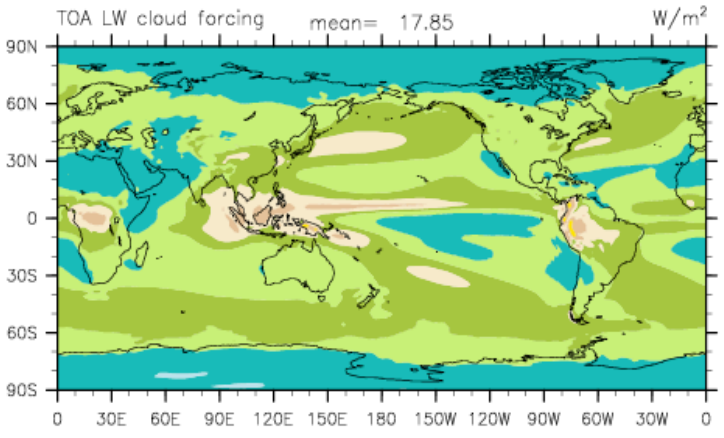


NCEP_GFS (yrs 11-50)



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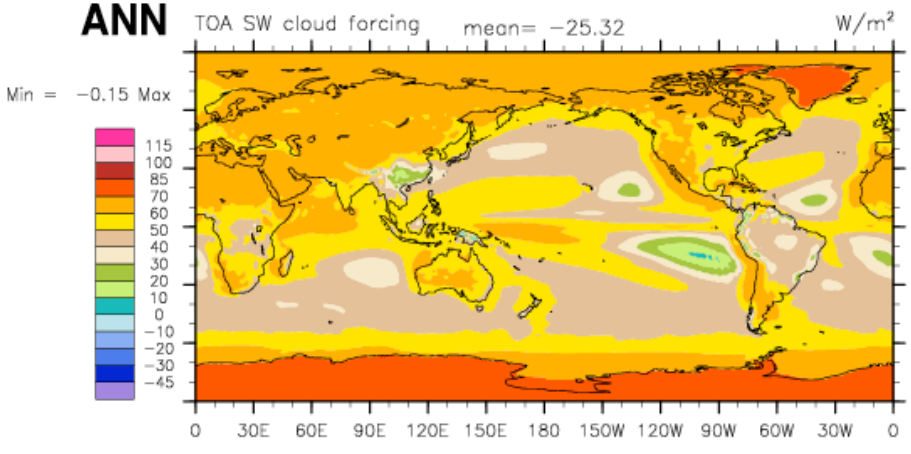

NCEP_GFS (yrs 11-50)

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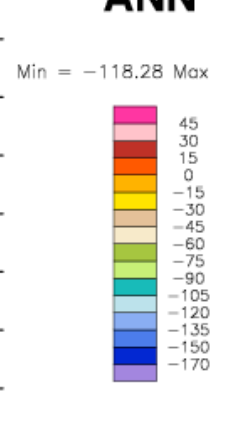
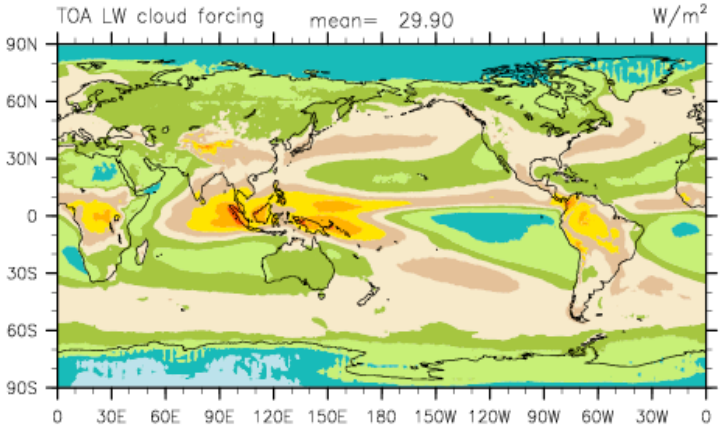
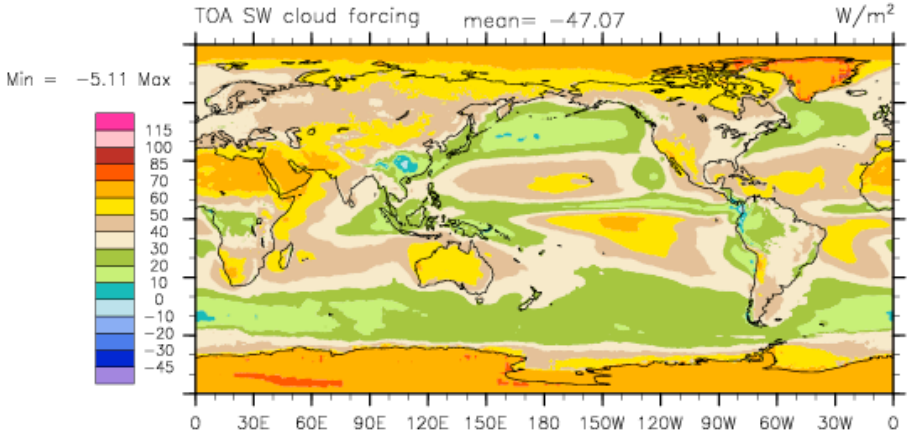
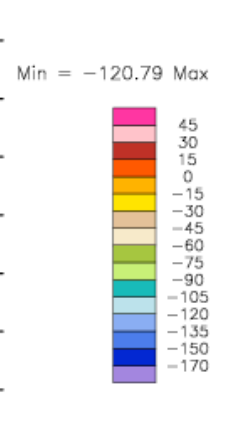


CERES2





CERES2



NCEP and unified weather-climate modeling …personal perspectives

- Weather forecasts are an excellent testbed for developing the ‘fast physics’ of climate models (as CFSv2 shows)
- CFSv2 and GFS are a partly unified modeling effort (new CFS versions rely on GFS development but not vice versa)
- A fully unified UKMO-style weather-climate model might facilitate taking GFS and CFS ‘to the next level’
- It could benefit climate-quality data assimilation and U.S. climate research.
- It could also entrain both the academic community and collaborations with other U.S. climate modeling centers
- This would require a large national commitment with strong leadership and extensive funding from outside NCEP.
- Are NCEP’s operational requirements too tight to allow such an effort?

Useful intermediate stepping stones?

- A systematic project for parallel weather hindcast testing of CFSv2 and other U.S. climate models (using a skillful 'neutral' initial condition such as ECMWF) to assess their strengths and weaknesses as weather forecast models.
- A project to develop comprehensive, user-friendly, on-line technical documentation of CFS and GFS.
- Careful analysis of GFS and CFS systematic bias evolution at leads less than one month, and its relation to their climatological biases.
- Evaluation of changes in operational GFS skill as a seasonal climate forecast model before making major model changes.